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JAPAN'S GROWING ROLE IN U.S. RESEARCH: BANE OR BOON?

Summary

The growth in foreign financial support of U.S. research and development efforts over the past several years has featured increasing interest from Japan, including rising outlays by Japanese corporations. A continued, strong and comprehensive effort by Japanese companies to keep abreast of and tap into American research and innovation is another facet of the growing interdependence of the U.S. and Japanese economies.

This expanding Japanese presence has stimulated concern among some U.S. policymakers that Japanese companies not only are skimming the "cream" of American R&D but are doing so at U.S. taxpayers' expense. As developing new technology becomes an increasingly critical determinant of global competitiveness and more and more expensive as well, American policymakers are weighing the costs and benefits of their open-door policy on foreign access to U.S. R&D, particularly where tax dollars are involved.

Foreign Research In The United States

While most Americans today might think that the United States always has played a dominant role in scientific research and industrial innovation, this is not the case. Prior to World War II the United States was a net technology absorber, although Americans did make significant contributions to the warehouse of human knowledge. In the postwar period the United States was the only major power with its scientific resources, both human and physical, mainly intact and able to support civilian and military pursuits. In addition, many European scientists and engineers emigrated from war-torn countries to the United States, further bolstering the American postwar advantage in research and development.

Two U.S. traditions have played a major role in shaping foreigners' participation in American research and development:

- An open-door policy on scientific research - Wide dissemination and open discussion of scientific research widely is perceived as a key source of vitality for the U.S. research establishment. Publishing research results not only allows scientists to establish a reputation and win the plaudits of peers but gives others a chance to critique the results, a process aimed at leading to still better science. Open discussion of research also may trigger new ideas and approaches, which, in turn, can generate new research topics. The interplay between one branch of science borrowing research results and methods from another has led to big breakthroughs in the past and is growing more important as new technologies with wide applications are developed. Foreigners have been welcome as part of the U.S. research community and have contributed much to the rigor and vitality of scientific debate here.

- Easy access to U.S. universities for foreign students - The excellence of U.S. institutions of higher education long has been recognized abroad and consequently has attracted significant numbers of undergraduate and graduate students. American universities have welcomed foreign students not only because they add diversity to the student body but because their enrollment in some fields compensates for a dearth of American students. (Fees paid by foreign students also can be much higher than tuition charged Americans.)

Thus, in the postwar years at least, foreigners have been a constant feature of the American research community and have supported U.S. R&D with their labor and ideas. Many foreign science and engineering students have stayed in the United States after graduating, further bolstering U.S. technological resources. Until recently the role of foreigners in U.S. R&D has generated little comment or controversy. Two developments, however, ignited a debate over the wisdom of continuing this open-door policy.

Growing foreign financial support of U.S. research. Research spending by foreign-owned or controlled companies in the United States has been expanding not only in absolute amounts but relative to total U.S. R&D outlays, according to data collected by the Department of Commerce and analyzed by the National Science Board (see Table). Total foreign research spending in the United States grew from $933 million in 1977 to $7,382 million in 1988, the latest year for which data are available. From 1978 through 1982 foreign research outlays rose by more than 20 percent annually, peaking at growth of 59.8 percent in 1981. From 1983 through 1988 the increase in spending moderated but remained between 11 and 14 percent.

Growth in foreign spending outpaced the rate of expansion in overall U.S. research expenditures as shown by the rising share of foreign outlays, measured in current dollars. Beginning at 2.2 percent in 1977, foreign spending's share rose to 3.1 percent by 1980 and hit a plateau of 4.7 percent from 1982 to 1984 before rising again in the last half of the 1980s. While foreign spending still is a relatively small portion of the total spent on U.S. research, its faster pace of growth has raised eyebrows in industry, academia and government.

U.S technological leadership challenged. After rapidly rebuilding their war-torn economies the European countries and Japan are making a bid for technological parity or leadership in consumer and industrial products, in particular. While the Europeans have tended to specialize in a few fields or have developed a handful of globally competitive firms, Japan is challenging the United States across nearly the entire spectrum of manufacturing with many intensely competitive companies. The Japanese have attracted special attention in this area for several reasons.

- U.S. market penetration - Capitalizing on manufacturing cost advantages and rapid product innovation, Japanese firms have gained significant shares of important or highly visible American markets. Japanese products play big or leading roles in U.S. markets for cars, televisions,

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Foreign R&D Expenditures in the United States, 1977-1988

(in millions of dollars and percent)

a. versus total U.S. R&D expenditures

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Total Expenditures	$42,783	$48,128	$54,953	$62,610	$71,868	$80,018	$89,139	$101,139	$113,818	$119,529	$125,352	$133,741
Foreign Expenditures	933	1,230	1,584	1,946	3,110	3,744	4,164	4,738	5,240	5,804	6,521	7,382
Share	2.2%	2.6%	2.9%	3.1%	4.3%	4.7%	4.7%	4.7%	4.6%	4.9%	5.2%	5.5%

b. by country

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Japan	$23	$54	$77	$88	$142	$141	$171	$210	$267	$292	$307	$515
Canada	74	85	102	135	777	1,032	1,212	1,405	1,550	1,542	1,666	*
Europe	790	996	1,253	1,544	1,936	2,229	2,324	2,632	2,918	3,450	3,881	4,403
France	62	89	56	146	204	232	215	261	166	352	366	419
Germany	101	189	311	380	436	529	591	602	671	851	1,139	1,180
Netherlands	190	215	244	299	373	397	387	432	514	517	542	597
Sweden	10	12	14	36	53	54	62	63	116	141	128	162
Switzerland	241	287	352	338	416	447	463	546	625	744	765	898
United Kingdom	155	176	252	312	405	520	559	664	748	764	833	1,042
Other	31	28	24	33	49	50	47	64	78	81	108	105
Latin America	35	73	132	*	*	*	401	423	427	427	391	366
Other	11	22	20	*	*	*	56	68	78	93	276	*

*Data withheld to avoid disclosing operations of individual companies.

Source: National Science Board, *Science and Engineering Indicators, 1991*, pp. 306, 346.

audio and video equipment, telecommunications gear and industrial machinery; these were all areas in which the United States previously held sway.

- Dominance of "key" products - Japan's rapid accession to top ranking in the global market for computer memory chips and other electronic components met with disfavor among some American observers who saw it as a major threat to U.S. economic growth. While proving reliable and economic suppliers of high-quality products to both civilian and military sectors (see *JEI Report* No. 33A, August 28, 1992), Japanese computer chip makers have failed to leverage their control of various components into leadership of downstream products. Computer memory chip operations have consumed a growing portion of capital and research budgets without producing large profits. The Japanese oligopoly also has attracted — in true free-market fashion — new competitors, primarily South Korean companies. Thus, to date the "threat" has proved overblown.

- Growing investment in the United States - Japanese companies' purchases of minority or controlling shares in American high technology companies skyrocketed over the past decade. Thanks to the appreciation of the yen against the dollar and a flood of inexpensive capital during the second half of the 1980s, Japanese firms appeared to go on a buying spree in the United States. Besides large green-field manufacturing plants and high-visibility real estate assets, news accounts and private studies cited high technology start-up companies as prime targets of Japanese investment. Because many of these start-ups involve current or former university researchers, there has been some debate whether public funding of academic science translates into an indirect subsidy to foreign companies. It is not clear, however, whether these investments have led to significant transfers of technology to Japan or whether the benefits of Japanese investment outweigh any potential disadvantages.

Another aspect of the investment issue is the growing number of Japanese firms setting up research operations here or adding them to an existing U.S. presence. Many of these facilities are located near academic institutions with good R&D reputations or near hotbeds of industrial innovation with the clear goal of tapping into ongoing developments and the flow of information.

A third facet of this question is the growth of Japanese investment in academic research. Japanese corporations have endowed research chairs at American colleges and supported the construction of new research facilities. Universities with strong research capabilities often have industrial liaison programs specifically designed to enhance cooperation with the private sector on R&D. Not surprisingly, Japanese firms participate in these ILPs right alongside American and other foreign companies. Japanese firms also are active (just as American companies are) in hiring American academic researchers or forming commercial partnerships with them.

- Growing Japanese share of U.S. patents - Foreign applicants steadily are adding to their share of total American patents granted each year, with Japanese firms at the head of the list. In FY 1991 the U.S. Patent Office granted Japanese companies 21,464 out of a total of 101,860 patents or 21.1 percent. Germany was a distant second with 7,548 patents granted (7.4 percent). Furthermore, three Japanese companies, Toshiba Corp. (1,156), Hitachi, Ltd. (1,139) and Mitsubishi Electric Co., Ltd. (959), placed first, second and third, respectively, in the number of patents granted to individual companies. (Canon Inc. was sixth with 828.) Studies of the "quality" or significance of patents also indicate that Japanese filings in certain fields are increasingly important.[1]

- Lack of foreign success in Japan - Each of these Japanese success stories in the United States seemingly has a negative mirror image of American experiences in Japan. Until recently American companies were unsuccessful at penetrating high technology markets in Japan, much less dominating them. Although the United States does lead the list of foreign investors in Japan, opportunities for foreigners to buy control of Japanese companies at the leading edge of technology have been very few. Japan's patent system has a notorious reputation for lengthy patent processing periods and ineffective protection of intellectual property rights. These American problems serve only to highlight more starkly Japan's success.

Bane Or Boon?

When U.S. technological and industrial superiority was unquestioned, foreign participation in America's research community was not an issue. The relative decline of American scientific dominance, especially vis-a-vis Germany and Japan, plus the end of the Cold War have focused much attention on the factors that contribute to economic competitiveness, including R&D. In an era of intensifying global economic competition as well as limited government and private financial resources, Americans actively are debating the costs and benefits of a continued open-door policy on foreign access to U.S. science and technology resources. The main areas of concern can be summarized as:

- Is the United States becoming reliant on foreign support for R&D. While this clearly is not true in an overall sense, the concentration of foreign interest in specific, important fields is a concern.
- Are foreigners benefiting more from U.S. research than Americans? Are foreign firms somehow using their well-developed technology-gathering networks to get a jump on technologies developed in the United States?
- Are U.S. tax dollars subsidizing foreign research without adequate recompense? Washington supports research directly, with projects and grants, and indirectly via tax breaks for corporate R&D spending. Because foreign firms take full advantage of university and federal research, some Americans claim that taxpayers are subsidizing foreign competition.
- Should foreign firms be free to buy U.S. technological assets? The sensitivities that formerly concentrated on foreign investment in defense-related firms have shifted somewhat to the competitive impact of foreign investment in U.S. high technology.

All sides of the debate agree that the United States has built a wonderfully productive research system and that one ingredient of its productivity is openness, even to foreigners. The issue boils down to whether the benefits of this system still accrue mainly to domestic entities. If not, the question becomes how can Americans regain positive benefit balance.

Human Resources

The transfer of technology can take many forms, including trade in components and finished products, patent licensing and cooperative research. Most students of the subject concur that the most powerful form of technology transfer is the exchange of individual researchers. While technology can be accessed from writings or by knocking down products embodying the know-how, these are pale substitutes for the knowledge gained by hands-on development of technology: such knowledge often cannot be, or is not, written. This is a key reason, besides wanting to take advantage of top-flight U.S. research, that foreign companies send employees to work in American research facilities.

Data on this question are not abundant. According to the National Science Board, foreign students as a proportion of all science and engineering graduate students rose from 20.2 percent in 1983 to 25.6 percent in 1990.[2] The foreign share of just science students seeking master's degrees increased from 16.7 percent to 22 percent over the same period; the respective figures for engineering students were 29.6 percent and 34.9 percent. The picture changes when doctoral candidates in science and engineering are considered. In 1980 foreigners represented 4.3 percent of science candidates, 12.1 percent of engineering candidates and 5.4 percent for both fields combined. Ten years later, the respective figures were 4.4 percent, 7.7 percent and 5.1 percent. The drop-off in the foreign share of engineering doctorates appears to have been due to slow growth in the number of foreign candidates (299 in 1980 versus 376 in 1990) combined with strong growth in enrollments by Americans (1,255 versus 1,927, respectively).

Data specifically on Japanese researchers in the United States are even scarcer. According to the Ministry of Education, a total of 764 researchers receiving a government subsidy of some sort (either for all expenses or just travel expenses) were sent overseas for periods of six months or more in

1990. That number was more than double the 319 government-funded researchers who went abroad in 1970. Of 1990's total 527 were enrolled in science studies and 237 in literature. Another 415 researchers were sent abroad to attend conferences in 1990. Neither a breakdown of the number sent to the United States nor Japanese data on the number of company employees in American laboratories are available.

A 1988 General Accounting Office study indicated 3,597 foreign researchers were at work in 50 federal laboratories and another 2,080 were participating in research through education programs at these federal labs in FY 1986.[3] This compares with figures of 4,657 and 8,435, respectively, for American researchers that year. Thus 30.2 percent of the researchers at the U.S. federal laboratories included in the survey were foreigners at those facilities. Among all foreign researchers in the survey 758 were Japanese nationals (13.4 percent); researchers from the United Kingdom (448 or 7.9 percent) and the People's Republic of China (438 or 7.7 percent) were next most numerous. Of the 452 Japanese doing actual R&D and not here for study or teaching, 193 (42.7 percent) were from nonprofit organizations, 92 (20.4 percent) were from the Japanese government and 27 (6 percent) from the private sector. The most popular institution for Japanese researchers was the National Institutes of Health (394) followed by the Department of Energy (245). Within DOE the majority of Japanese researchers focused on energy subjects (191); the remainder worked on defense programs (54).

While far from comprehensive the above data do show that Japan contributes relatively significantly to the makeup of foreign researchers in the United States. The information on Japanese researchers at U.S. federal laboratories is particularly interesting, though dated, because it reveals Washington's relatively open foreign access policy. Critics complain that the paucity of data since the GAO study was conducted poses an obstacle to informed policymaking on U.S. R&D issues.

Government-Sponsored International Research Projects

In response to foreign pressures to boost contributions to global science and technology know-how the Japanese government is sponsoring research by foreign companies at overseas locations, among other activities. Tokyo also has extended a welcome mat to researchers from foreign universities, companies and government laboratories via a number of programs:

- Human Frontiers Science Program - Announced in 1986 by then Prime Minister Yasuhiro Nakasone, HFSP's goal is to explore basic biological functions of the mind and body. Tokyo originally proposed to put up at least half of the ¥1 trillion ($7.4 billion at ¥135=$1.00) cost and solicited the participation of foreign scientists not only as researchers but as project leaders as well. Another innovation was that the research could be conducted abroad in the facilities of the foreign scientists winning contracts. Since overcoming foreign suspicions about the program by setting up an independent foundation in Strasbourg, France for administrative purposes and by agreeing to foot most of the bill, Tokyo has handled a steadily growing number of funding applications. In FY 1989 it granted 29 of the 239 applications for research grants and 80 of the 202 applications for long-term fellowships. In FY 1990 the same number of research grant applications were received but 32 were granted; of the 348 fellowships sought, 104 were approved. In the fiscal year ending in March, 37 of 281 research grant requests were accepted and 128 of 499 fellowship applications were approved. A total of 77.5 percent of the long-term fellowships and 70 percent of the research grants in FY 1989 went to foreigners, shares that dropped in FY 1991 to 76.5 percent and 32.4 percent, respectively. American researchers and institutions have received about one-quarter of the funds awarded so far. Tokyo also is devoting more funding to HFSP. The sum of ¥1.2 billion ($8.9 million) in FY 1988 climbed to over ¥3.8 billion ($28.1 million) in FY 1992.

- High-Speed Civilian Transport - Beginning in the mid-1980s Tokyo actively sought foreign participation in government-industry R&D programs. While a few of the projects have involved Japanese subsidiaries of foreign firms, a few directly enlisted foreign companies doing work overseas. One such project was initiated in FY 1989 to develop a Mach-5 civilian transport aircraft. General Electric Co., the Pratt & Whitney division of United Technologies Corp., Britain's Rolls-Royce,

and France's Snecma, are collaborating in the design of a complex combined-cycle turbojet-range engine for the hypersonic craft. Foreign firms are slated to receive about 25 percent of the ¥3.8 billion ($28.1 million) appropriated in FY 1992 for the project. This phase of the HSCT development is expected to last about eight years and cost ¥44 billion ($325.9 million). Work seems to have gotten off to a good start with the mid-February 1991 signing of contracts. According to Yuichiro Takanemai, former director of hypersonic projects for the Ministry of International Trade and Industry, "Foreign companies and governments are careful about technology transfer. It's just been one year but they're doing well, with a two-way flow of technology."[4] As the combined-cycle engine takes shape, testing and evaluation of various components will take place at U.S. facilities of the American participants. Foreign firms may win roles in follow-on projects to build and test actual flying prototypes.

- The latest MITI-sponsored project to attract foreign participation is aimed at developing industrial and medical robots less than 1 millimeter in size. A 10-year ¥25 billion ($185.2 million) micromachines project began with the fiscal year that started in April. Participants include Texas Instruments Inc., SR Robotics Corp. and SRI International Inc., with 24 Japanese companies and researchers from Australia's R.M.I.T. Victoria University of Technology. The first five-year phase will focus on manufacturing and processing the special materials required while the next five years will work on actual fabrication of working devices.

- Intelligent Manufacturing System - Initially suggested by MITI in late 1989, this project originally aimed to develop an integrated computer system to conceive, design, produce and distribute manufactured products. MITI hoped to provide two-thirds of the estimated ¥150 billion ($1.1 billion) cost of the 10-year project, with the remaining funds coming from other members of the Organization for Economic Cooperation and Development. Foreign companies and universities would be welcome to submit research proposals and conduct the work in their home facilities. Worried that IMS would lead to the erosion of the U.S. position in certain fields, Washington stepped in under the aegis of the 1988 bilateral science and technology agreement. Besides requesting that MITI solicit a consensus from American companies about the wisdom and the benefit of joining IMS, the Commerce Department asked that the ministry channel all discussions about the program through Commerce rather than engage in direct talks with U.S. firms. At the latest session of talks held in late July, the main topics were how to structure test cases for cooperation and how to manage intellectual property rights. Also being examined are how to balance costs, share benefits and determine control of test cases. One or more test cases will be picked from six topics: enterprise integration, global manufacturing, system component technologies, clean manufacturing, human and organizational aspects, and advanced materials processing. The test cases also will serve to develop guidelines on how to handle intellectual property rights to the results of joint research.

- Real-World Computing Project - This successor to Tokyo's Fifth Generation Computing Project still is in the formative stage but has encountered many of the same delays as IMS. Aiming to develop massively parallel computers using optoelectronic components that could be as flexible and powerful as the human brain, MITI sought foreign input during the feasibility study phase (see *JEI Report* No. 42A, November 8, 1991). By seeking foreign input one step earlier in the planning process than it did with IMS the ministry underscored the importance of foreign ideas in advanced computing, since much of the leading-edge research is being done outside of Japan. Precisely because American firms have a perceived edge in this field, however, Washington again made U.S. participation in RWCP a subject of government negotiations. After a year of discussion Washington has decided to limit U.S. participation in the project, for the time being, to developing equipment to test and evaluate optical computing components.

Tokyo has added funds for foreign research activities to its R&D policy pallette, but its efforts are still in the early stages and encountering difficulties. Nevertheless, the more open stance by the Japanese government counters some of the arguments raised by those who fear America's research doors serve only one-way traffic.

Company Research

While Japanese government actions are noteworthy, the activities of Japanese corporations have received greater attention for several reasons. Japan-based companies have developed broad technology-gathering operations in the United States and other countries, including ties with universities, businesses and foreign governments; this can present the appearance of predatory technology gathering, even industrial espionage. Moreover, in Japan leading-edge research is conducted primarily within Japanese companies, which generally neither welcome foreigners into their laboratories nor encourage information to flow freely out their doors. Unlike government efforts at two-way flows of information the corporate attitude raises questions of equal access. But most important, Japanese companies have built a fearsome reputation for rapidly translating basic and applied research, especially foreign research, into commercial products.

Most Japanese companies that export to the United States built some kind of representative presence here to support their trade. As trade evolved and deepened, many companies added research functions to existing operations. This "research" first took the form of market research or tried to find ways to adapt products to local market needs. Once manufacturers began to localize production, more concerted research efforts followed closely. In recent years a number of Japanese companies have begun doing scientific and engineering research in the United States, either by expanding the scope of existing research operations or building new dedicated facilities.

There are several reasons for this surge in "real" research by foreign firms in the United States. Scientific or technological expertise in specific fields often is narrowly concentrated geographically; taking advantage of specialized talent usually requires a local presence. One reason that Japanese managers give for the ability of Japanese firms to quickly move technology from the laboratory onto the factory floor is the close proximity of research facilities to production lines and the constant interchange of researchers and line workers. As stated above, corporate research labs tended to follow Japanese firms' development of localized production facilities. Finally, there has been a sharp increase in the number of cooperative research agreements between Japanese and American companies, reflecting the complexity and higher costs of advancing the state of the art.

According to an annual survey by the Japan External Trade Relations Organization, an arm of MITI, more than 360 Japanese companies conduct R&D activities in the United States.[5] While many of these firms station the R&D facilities close to their factories, some locate them to take advantage of strong research resources. Several Japanese pharmaceutical companies, for example, have laboratories in Maryland, close to the National Institutes of Health and Johns Hopkins University, both centers of top-flight biological research. Foreign R&D centers also are situated near leading U.S. universities or concentrations of high technology companies, such as the so-called Silicon Valley area in California.

Japanese research facilities in the United States are quite diverse in size, purpose and subject matter. This reflects not only the extent to which the U.S. and Japanese economies have become intertwined, but the degree to which Japanese companies are becoming globalized and the richness of American technology resources. While operations focusing on market research still dot JETRO's listing, most R&D operations focus on specific applied research, such as steel, drugs, electronics components and ceramics. Japanese automakers have upgraded their American exterior design studios to full engineering workshops. Some care is necessary in interpreting JETRO's list, however. Many of the research operations listed in Washington, D.C. focus primarily on intelligence gathering and maintaining links with the U.S. bureaucracy; little, if any, actual research is conducted in these offices.

The Department of Commerce has examined the implications for U.S. technology development of the growing number of U.S. subsidiaries of Japanese companies. Citing Bureau of Economic Analysis data, the study reports that research spending by all U.S. affiliates of Japanese firms more than doubled from 1988 to 1989, jumping from $307 million to $770 million.[6] Through the first half of 1991, the study revealed, 31 Japanese electronics firms opened 70 research centers. This is

far higher than the 21 European-affiliated laboratories that have opened. The number of Japanese R&D units continues to grow. Not surprisingly, semiconductors is the most common field, comprising 13 operations. Computers and software, tied at 12 each, follow in number with telecommunications equipment firms having eight facilities and advanced television research five. The Commerce study warns about the difficulties of assessing the true impact of Japanese corporate research here. Among its stated caveats are: a portion of the research is directed at marketing or localizing existing products; a portion is for intelligence gathering; the definition of "research" may be different among Japanese firms as compared with American ones; and the size of research operations is not taken into account. The study also points out that neither the contribution nor the impact of research conducted by American companies that have been bought by Japanese firms was considered.

It is apparent from the JETRO and the Commerce surveys that the great majority of Japanese research in the United States is focused narrowly on commercializing technology. Within the past few years, however, several Japanese firms have opened facilities to explore more basic science and research. NEC Research Institute Inc. opened its Princeton, New Jersey doors in 1990, representing parent NEC Corp.'s plunge into the American basic science community. Built at a cost of about $32 million and supported by an annual budget of roughly $26 million, the institute has recruited about 45 American scientists from academia and businesses.[7] A five-person board of scientists selects and funds research projects, which means they -- rather than the parent company -- essentially exercise control. While research supposedly is undirected and emphasizes new, risky areas of inquiry, most current topics clearly relate to NEC's lines of business. Work on neural computers, artificial intelligence, fuzzy logic, superconductivity and optoelectronics all eventually could be embodied in NEC products. Ties with the parent company also are close. NEC equipment in the laboratory is common, and institute scientists often collaborate with NEC researchers in Japan. While research results are discussed openly and published, it is not clear how intellectual property rights are handled. If NEC has an exclusive right to license patents resulting from the institute's work, the institute's benefits that accrue to the United States clearly are reduced. Some would argue that by hiring away elite researchers from American universities and companies the institute also erodes the U.S. research base. The Americans at the institute strongly dispute this point, contending that they can do better and more science since they do not have to worry about funding. Americans and Japanese will be watching NEC's institute carefully in the coming years, weighing its benefits and costs.

Corporate Research Ties With Americans

Besides conducting research within their own organizations, Japanese companies cultivate ties with American scientists, ranging from those in corporate America to U.S. private and public universities as well as to connections with the federal government's research establishment. Because few technology resources are overlooked, critics have characterized this comprehensive effort as an "unfair" competitive tactic employed by Japanese companies. This perception overlooks the openness of the U.S. system in which much information is gleaned from public sources, allowing intelligence-gathering efforts to take place openly. This means that the Japanese companies are not receiving special treatment -- American firms can (and do) operate exactly the same way.

Ties to U.S. government laboratories - Washington and Tokyo often have agreed in the past to pursue jointly some areas of research. One area of long-standing cooperation focuses on peaceful uses of nuclear power. The federal government understands that its vast research system could assist the competitiveness of the private sector and has several programs designed to foster the transfer of technology. Japanese firms have taken advantage of these opportunities, too, sometimes dwarfing the interest shown by American companies. Japanese-owned firms outnumbered their U.S. counterparts 25 to 1 when Oakridge National Laboratory experimented with an open-door policy in the mid-1980s; the policy was altered to prevent controversy from developing over the Japanese predominance.[8]

Two interrelated developments are forcing federal laboratories to open their doors even wider to the private sector. First, the end of the Cold War means that some defense-related research will be

less vital. Washington's pledges to cut the number of U.S. nuclear weapons, for example, probably will lead to less money for research in this area. This situation leads to the second factor: declining R&D budgets for federal facilities that previously focused on defense. To address both these developments federal laboratories are changing their priorities, putting a greater premium on commercially useful technology. Federal labs hope that by boosting the competitiveness of American companies they themselves will continue to prove their value and support their claim to a piece of the budget pie.

It is almost certain that Japanese companies (either directly or through their U.S. subsidiaries) will avail themselves of the new open-door policy set by federal laboratories. Because the government facilities still are determining the structure and the limits of the new policy, it is not clear whether special provisions for foreign firms will be included. Federal laboratories certainly would not aid their own cause if they left themselves open to charges that they were assisting foreign competitors with U.S. tax dollars. Participation by foreign firms, however, could benefit the American economy not only through program fees but through technology and information exchanges. The cost/benefit analysis of such situations often is not made easily.

Ties to U.S. universities - The American taxpayer directly and indirectly funds a vast system of higher education that serves as a hothouse of scientific inquiry and technological innovation. American companies long have benefited from academic research in many forms: through research they have funded, the professors and the graduates they have hired, the published research results, the scientific conferences open to them, and the useful technology made available for them to license. Japanese firms have followed similar approaches in building ties to U.S. universities for both business and philanthropic reasons. Universities themselves have reached out to the private sector to foster the transfer of technology. Schools with strong research resources have established industrial liaison programs that give businesses a window into ongoing work for a price. While it is difficult to criticize Japanese firms from behaving exactly as American companies by tapping into the technology resources of the U.S. university system, two areas have received the bulk of attention.

- Japanese funding of university research - A 1988 GAO report estimated that foreign funds made up less than 1 percent of the total R&D budget of 134 public and private universities that participated in the study.[9] Of the $74.3 million in total foreign funds, Japan provided $9.5 million (12.8 percent), second only to West Germany, which was the source of $16.3 million (21.9 percent). Fifty-three universities reported receiving funds from Japanese sources in FY 1986, with four receiving the bulk: Texas A&M University (26 percent), Massachusetts Institute of Technology (23 percent), University of Wisconsin (14 percent) and University of Washington (4 percent). Interestingly, the GAO survey showed that geology departments received the most foreign funding ($16.4 million), followed by agriculture ($11.5 million), medicine ($8.4 million), civil engineering ($2.7 million) and chemistry ($2.6 million). Computer engineering ($1.1 million), materials engineering ($1.3 million) and electrical engineering ($0.7 million) fared more poorly than might have been expected. The GAO study concluded that foreign funding in FY 1986 constituted only a small part of total university research outlays. While most universities did not report special rules for handling foreign funds, "where there are differences, U.S. universities tend to place greater restrictions on foreign than on U.S. sponsors."[10]

Using data mandated by Section 1209 of the Higher Education Act of 1965, the Center for Public Integrity presents a more complex picture of Japanese funding channeled to American universities.[11] Section 1209 required institutions to report gifts or contracts with foreigners to the Secretary of Education from FY 1986 through FY 1989 if the sums totaled $250,000 or more within a calendar year. By comparing these reports with the institutions' annual reports on contributions the center found that some institutions were not disclosing all funds received from Japan in their annual reports on contributions. In fact, 10 universities did not list Japan as a contributor between 1986 and 1989 even though they had received $500,000 or more. The University of California at Irvine, for example, included no Japanese funds in its annual review but reported under Section 1209 having received $16.5 million. MIT also listed no Japanese funds in its public report but showed receiving

more than $5.8 million in its report to the Department of Education. The top 13 institutions as ranked by their public disclosures of donations from Japanese sources listed only $6.8 million. In their reports to the government they disclosed an additional $46.2 million. The center's report does not delve into why these funds were not included in the public reports; most of the funds were used to build research facilities and other works that directly relate to the universities' research activities. Although the reporting requirement lapsed in 1989, the nonprofit Washington, D.C.-based public interest group asserts that American colleges received more than $175.7 million from Japanese sources, including firms, nonprofit groups or quasi-governmental organizations, through 1991.

Beyond the absolute amount of funding are questions regarding the conditions under which the money is provided. Policymakers' primary concern is whether universities are so desperate for funds that they will agree to conditions highly favorable to the donor company. Critics cite as examples of questionable contracts those deals where Japanese company researchers have access to university work but not vice versa, and to contracts that give Japanese firms first or exclusive rights to license the results of research. Universities retort that they are not violating any federal law and that it is not up to them to establish a national policy in this area. Each institution makes what it feels is the best bargain, especially since Japanese firms are more willing than American companies to fund research with uncertain commercial applications.

- **University Industrial Liaison Programs** - MIT was the first American university to create a framework that gives the private sector a "window on emerging technologies" under development by academia. MIT's program, established in 1948, features special symposia for corporate members, visits to university laboratories, meetings with faculty and university administrators, and updates on research of special interest to members. American companies pay an average of $33,000 annually to participate in MIT's program while foreign firms pay an average of $46,000.[12] Thirty-nine other U.S. universities with strong research resources have created industrial liaison programs. To attract additional Japanese members and to foster MIT's access to Japanese technology, the institute opened an office for industrial liaison programs in Tokyo in 1975. Only two other schools — the University of California at Berkeley (1988) and Carnegie-Mellon University (1990) — have taken a similar step.

The controversy over university ILPs revolves around two questions. Are foreign companies being subsidized by the American taxpayer through the government's vast support for university research, and are foreign companies benefiting more from ILPs than American firms? Critics argue that foreign ILP members benefit from the vast American investment in universities without paying for it. While membership fees cover some current research expenses, the cost of building the research infrastructure, both human and physical, is not reflected in the annual fee. In essence, critics argue, foreign members should pay a fee that reflects these previous investments.

On the second question, critics point to some ILPs that give members a preview of research results before they are published openly. Foreign members thus can become aware of a new technology before most American firms, which may pay taxes to support the school but are not ILP members. While the delay between preview and public announcement of research results might be only a few months, in some rapidly changing, highly competitive industries even this brief advance notice can be an advantage.

Among other questions being debated regarding Japanese funding of American university research and foreign participation in university liaison programs are: Should a reporting requirement like Section 1209 be reinstated or made permanent? Should there be special federal rules for foreign funding of university research? How is a U.S. subsidiary of a foreign firm classified for participation in ILPs — particularly if it pays U.S. taxes? More data and discussion are needed before these questions can be addressed intelligently and appropriate policies implemented.

Ties to U.S. companies - Licensing of patents held by foreign competitors is a mainstay of the competitive tactics of Japanese corporations. Because they were technologically behind after World

War II, Japanese firms reasoned that the most cost- and time-efficient way to catch up was to license foreign know-how. Aided by the bureaucracy and by foreign willingness, Japanese companies obtained licenses to basic technologies at much less cost than if they had had to develop them themselves. Patent licensing still constitutes the biggest channel for technology transfer between the United States and Japan, with the flow predominantly from the United States to Japan although the imbalance is shrinking. (See *JEI Report* No. 28A, July 24, 1992 for detailed data on patent licensing transactions.)

A rapidly developing phenomenon is joint research, in which American and Japanese companies form strategic alliances to spread the high cost of developing new technology, improve the chances of success (two approaches may be luckier than one), and limit the impact of failure. Moreover, sharing costs of one project can permit other research to be funded simultaneously. (For a discussion of research consortia, see *JEI Report* No. 21A, June 5, 1992.) Alliances in microelectronics, for example, are sprouting as the cost of chip plants and microchip process developments rise into the billions of dollars. The world's automotive industry, too, is restructuring as individual companies pick partners and form alliances.

Debate over research arrangements between Japanese and American firms echo some of those regarding ILPs. Are the benefits fairly distributed? Is the American taxpayer somehow subsidizing the deal? Will the transactions benefit the entire U.S. economy? Those concerned over the structure of joint research pacts worry that the Japanese use the lever of money to gain a disproportionate share of the benefits. Since the specific terms of each agreement vary, it is difficult to generalize. Because they are private contracts, imposing federal guidelines on joint research ventures with foreign firms probably would be inflexible and unwieldy. If an American company makes a bad deal, some economists would shrug and say that this is the free market in action. Critics of laissez-faire approaches counter that the technology assets involved in a commercial deal can be so important in some cases that federal involvement is necessary to safeguard the interests of the entire nation; the meanings of "important" and "safeguard," however, usually are left fuzzy.

In past years national defense issues have been the focal point of arguments about the potential negative impact of this micro/macro discontinuity. This discussion now is expanding to include U.S. commercial interests. In this context questions include whether the research would be conducted at all without Japanese participation. In some cases, the complementarity between U.S. and Japanese companies is a powerful argument in favor of cooperative research.

Ties to U.S. research consortia - American firms increasingly are joining forces to conduct research. In some instances the federal government lends a hand (or a buck). Sematech, a consortium of American companies committed to developing advanced semiconductor manufacturing technologies, is an example of how a foreign presence in American research can complicate the picture. Originally established in 1987 to answer the challenge of Japanese gains in semiconductor manufacturing equipment, Sematech relies on members to pool about $100 million a year for research. Washington agreed to match this commitment for the consortium's first five years. Since its inception Sematech has experienced controversies over its purchases of foreign equipment and its contracts with foreign-affiliated firms. Outside deals between foreign firms and individual Sematech members raised questions about the integrity of the consortium's proprietary technology. Rumors that the consortium was even considering joint research with foreign firms set off heated debate within the group as well as outside it. As strategic alliances become more widespread, as cooperative research becomes more common and as the Japanese and other foreign presence in the United States grows, controversies such as those experienced by Sematech will become increasingly common.

Japanese Direct Investment

Another long-standing phenomenon that has become increasingly controversial is the purchase of American companies by foreigners. Foreign capital has assisted American economic

development and growth since the country's birth. In response to the growing foreign challenge to American economic leadership and the sharp growth of Japanese direct investment here, various observers have questioned whether the United States should continue its laissez-faire attitude toward foreign purchases of technological assets.

According to the latest JEI study, Japanese acquisitions of American manufacturing companies in 1990 accounted for a greater portion of overall Japanese direct investment than ever before (see *JEI Report* No. 46A, December 13, 1991). Of 110 investments resulting in majority ownership in 1990, 65 were acquisitions of existing companies. This compares with 66 of 197 in 1988, and 74 of 189 in 1989. Some American observers fear that such takeovers allow the Japanese parent to transfer the technological assets of its new subsidiary back to Japan out of the public's sight and free of any interference from Washington. Anxiety over the consequences of foreign control is especially apparent when the subject of foreign investment has defense technology implications.

When confronting such anxieties it is helpful to inquire more deeply into the potential problems raised by foreign control. The main concern seems to be that a foreign-owned company is more likely to act against U.S. interests than a domestic company. This possibility could arise because of pressures applied by foreign governments, because of different values, or simply because of an insensitivity created by distance — the typical complaint against absentee owners. Policies to mitigate the potential problems of foreign control include diversification of technological linkages. This policy is often preferable to championing domestic contenders, which has the potential of creating permanent deficiencies. (See *JEI Report* No. 33A, August 28, 1992 for a look at related dependency concerns in the defense industry.) The issue concerning technology transfers and foreign investors has another side, however. While it is not clear whether such transfers are made back to the buyer's country, it is equally possible that the American subsidiary could be infused with technology from the parent firm or that the two could enter into joint research to the benefit of both. If backed by a parent with deep financial pockets and technology specialization of its own, the American subsidiary's research programs may be boosted rather than raided.

Some analysts have focused on Japanese funding of U.S. high-technology start-up companies, particularly in the electronics and biotechnology industries. It was feared that these new firms, desperate for capital, were making Faustian bargains with the Japanese, trading their technological jewels for money. The Japanese firms could buy access to some of America's most innovative companies for relatively little money. While there is anecdotal evidence that small U.S. electronics firms in the 1970s and early 1980s were failing to guard their intellectual property assets and not reserving enough geographic marketing rights for themselves, more recent reports indicate that American firms have begun to be much more careful about structuring their relations with foreign firms. The biotechnology industry had been a particular source of concern to those worried about technology transfer because Tokyo had made becoming a force in this new industry a national goal. Moreover, Japanese companies were eager to provide capital to American biotech start-ups. In this field, just as in the defense area, it appears that these fears were overblown.

The conditions attached to agreements whereby Japanese firms acquire American high technology companies or fund start-ups can alleviate many U.S. concerns. This lets each investment be judged on its individual merits. This approach recognizes the potential for American firms to benefit equally, if not more, from entering into a relationship with a Japanese firm. Plus, such a process encourages policymakers to clearly identify potential problems in advance so they can devise guidelines to ameliorate them.

Policy Options

At first glance it would appear that allowing foreigners to support U.S. research and development with both financial and human resources unquestionably would bolster America's technology base. When issues of control over the subject and the direction of research, ownership of

commercially usable results and the true cost of foreign-sponsored research to the American economy are examined, discussion becomes far from simple. Not even the harshest critics of foreign-sponsored research favor protectionist measures that somehow would block foreign access, however; such moves might hinder the free interchange of ideas and research results that invigorates America's research system. Developing options that address the attractiveness of foreign sponsorship of U.S. research but clearly assign costs and balance benefits is an issue confronting companies, universities, and, possibly, government officials.

Japan - Japanese companies hardly can be faulted for tireless pursuit at home and abroad of new technology, the key to competitive advantage in an era of knowledge-intensive industry. Nevertheless, a debate has begun in Japan over the continued wisdom of the no-holds-barred attitude of domestic companies toward economic competition (see *JEI Report* No. 15A, April 17, 1992). Any such change in the psychology of corporate management most likely will be incremental, requiring more time than Japanese or American researchers feel they can afford before resolving these issues of concern. Several options have been broached for more direct, immediate Japanese action:

- More government-sponsored foreign research - Programs like the Human Frontiers Science Program and the Real-World Computing Project highlight both the potential and the pitfalls of this approach. Overcoming foreign suspicions about ulterior motives behind government sponsorship of foreign research is proving to be a major obstacle. But, just as it took time to build a reputation for being a technology absorber, it will take time before Tokyo's reputation will evoke a more balanced image. Once a mutual agreement is struck on the structure for foreign participation, the government-sponsored international cooperative research projects can become a showcase of Japan's commitment to contributing to global science and technology.

- Improve access for foreigners to Japan's research system - One way to blunt foreign criticism that Japan benefits unfairly from tapping into research resources abroad is to give foreigners greater opportunities to access its domestic research system. Tokyo already has opened its research consortia to foreign participation. The government also sponsors several programs designed to place foreign researchers in national laboratories. The Ministry of Education has ambitious plans to upgrade the quality and the quantity of research conducted in Japan's universities, a resource that will be freely available to foreigners. Since the high cost of living in Japan, language difficulties and other mundane problems reduce the attractiveness of Japan to foreign scientists, Tokyo is beginning to address these issues, too, providing housing and daily expense stipends as well as language training and other support programs.

Another possibility being eyed is for more Japanese companies to open their research laboratories to foreigners and to foster a more balanced flow of technology between Japan and its trading partners. Because corporate Japan funds the majority of R&D there (see *JEI Report* No. 28A, July 24, 1992), much of the leading-edge work is shielded from outside view by proprietary concerns. Nevertheless, some Japanese companies are beginning to realize that they can benefit from greater foreign input, including critiques of their research operations. Many companies have guest researcher programs specifically designed for foreigners and are working to link their global research facilities into a seamless network. Even with greater openness, the Japanese corporate R&D world is unlikely ever to be as open as the American university system, however.

United States - Washington consciously has been seeking to improve access to Japan's research resources to blunt criticism of an unbalanced bilateral technology flow. Opportunities for foreign researchers in Japan are far more numerous today, in fact, than even five years ago. In addition to the language and housing problems mentioned above, there is an element of elitism that is preventing some Americans and U.S. companies from taking advantage of the new opportunities. Policies to help break the "not-invented-here" syndrome that blinds American companies to foreign technology resources and to support U.S. scientists who want to do research in Japan are well within the reach of Washington. Just as it will take time for the Japanese to adjust their attitudes, so will it take time for some Americans to change theirs.

Dealing more directly with the issue of foreign-sponsored research in the United States, Washington has several options:

- Improve data collection - It is difficult to develop good policies without sound information. Although some companies are reluctant to discuss sources and extent of funding, public disclosure may have a sobering effect on the excesses of foreign firms bent on using their funding to gain extraordinary advantages. More information on foreign activities at federal research facilities can be tracked easily and would benefit policymakers. A reporting requirement similar to Section 1209 of the Higher Education Act could be made permanent for a variety of public research labs.

- Charge foreigners for access - To nullify the advantage available to foreigners that might join a project funded by prior U.S. investment in its research system, American laboratories could ask foreigners to pay more. Foreign students might be taxed or charged a much higher tuition, much as out-of-state students pay higher fees at state universities. Foreign firms could face higher fees for membership in university industrial liaison programs or even a "technology access" tax that could be plowed back into the American R&D machine. Foreigners hoping to tap into federal R&D resources could be asked to pay a higher fee.

- Restrict participation by foreigners - Washington could determine that some research topics are too sensitive for foreign participation. While this is established practice for areas related to national defense, there is some debate about widening the criteria to include national economic interests. The problem is how to define these interests and where to draw the line. Restricting foreign access to U.S. R&D may lead to a backlash against Americans overseas, losing the few hard-fought gains Washington has achieved. Restricting foreign access also may prevent Americans from learning from foreigners or from taking advantage of foreign research strengths.

- Issue guidelines for terms of contracts - If the content of foreign agreements with U.S. universities or companies is a concern, it is possible for Washington to assert regulatory authority over these commercial transactions. Fears that this would become a bureaucratic nightmare have some justification. Any benefits gained by preventing "bad" deals (and guidelines to make this evaluation would be both necessary and difficult to draw up) might be overwhelmed by losses stemming from approval delays or discouraged deals.

- Seek Japanese funding for U.S. research - If Washington is worried about foreign control of American research via the purse strings, it can set the research agenda then seek accompanying foreign funding. This is what Washington is doing with its Superconducting Supercollider project, a mammoth high-energy physics research facility. Beginning with the Reagan administration, the White House has been seeking foreign funding to help defray the cost. Tokyo is at the top of Washington's preferred donor list, but the Japanese have not yet agreed to commit money. Bilateral talks are continuing. Just as Tokyo ran into foreign suspicions of its international cooperative research initiatives, so has Washington encountered similar hesitation abroad regarding its grand research ideas.

Conclusion

The debate over the costs and the benefits of foreign-supported U.S. research is complex and subtle. Factors influencing the discussion include the relatively small foreign share of total American research outlays, the foreign portion's faster paced growth than the overall total, and the concentration of spending in certain areas. The number of foreign researchers in the United States also is small compared to the total number of scientists and engineers. Foreigners can comprise a significant portion of the staff at specific institutions, however.

The benefits of foreign support of R&D in the United States are significant factors in the debate. Foreign researchers, particularly those from Japan, are highly qualified and do excellent work. It is not certain that similarly trained Americans would be available if foreign researchers were

barred from U.S. laboratories. Foreign researchers, with their different sociocultural backgrounds, also contribute to the vitality of U.S. science by providing a fresh viewpoint on issues and problems.

Japanese companies have a reputation for taking a long-term view of R&D and are willing to fund projects at home and abroad with payoffs well down the road. Fewer U.S.-originated projects may be funded if only American resources were available. Japanese firms that back U.S. research not only provide money but often contribute managerial skills to increase the productivity of research dollars. Foreign firms also can open a window to foreign technological developments, a window that Americans often ignore.

The legitimate questions that can be asked about foreign support for U.S. research, as it currently is structured, are many. Whether foreigners are paying a fair price for access to U.S. science and technology resources is one valid issue. Moreover, a long-standing American political-economic tenet asserts that agreements between knowledgeable consenting adults provide mutual benefits to the contracting parties. Price distortions from subsidies or a national interest that deviates from private interests could make some private transactions undesirable in a broader evaluation, however. In addition, a lack of information makes it unclear if an accurate and fair price can be determined. Whether research agreements with foreigners yield an acceptable balance of benefits to both sides is part of the debate. And whether the federal government should take action to regulate the content of these pacts is equally fair game for discussion. Officials' most productive activity might be to focus on policies that improve the quantity, quality and interchange of research not only in the United States but globally. As with trade in goods, more trade in ideas is preferable to protectionism from a theoretical standpoint.

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Notes

[1]Robert Buderi *et. al.*, "Global Innovation: Who's In The Lead?" in *Business Week*, August 3, 1992, pp. 68+.

[2]National Science Board, *Science and Engineering Indicators, 1991* (Washington, D.C.: U.S. Government Printing Office, 1991), pp. 260-261.

[3]U.S. General Accounting Office, *Technology Transfer; U.S. and Foreign Participation in R&D at Federal Laboratories*, (Washington, D.C.: U.S. General Accounting Office, 1988), pp. 16-23.

[4]"International Group to Build Combined-Cycle Hypersonic Engine," *Aviation Week & Space Technology*, August 17, 1992, p. 50.

[5]Nippon Boeki Shinkokai Kaigai Keizai Joho Senta (Japan External Trade Relations Organization, Overseas Economic Information Center), *Zai Bei Nikkei Seizogyo Keiei no Jittai — 1991 Nen Chosa (Dai Juichi Kai) (The State of Japanese Manufacturing Subsidiaries in the United States — 1991 Survey [11th Edition])* (Tokyo: Government of Japan, 1992), pp. 52-54.

[6]Phyllis A. Genther and Donald H. Dalton, *Japanese-Affiliated Electronics Companies: Implications for U.S. Technology Development* (Washington, D.C.: U.S. Government Printing Office, 1992), p. 13.

[7]Joseph Weber *et. al.*, "Pure Research, Compliments of Japan," *Business Week*, July 13, 1992, pp. 136-137.

[8]Genther, *op. cit.*, p. 5.

[9]U.S. General Accounting Office, *R&D Funding; Foreign Sponsorship of U.S. University Research*, (Washington, D.C.: U.S. General Accounting Office, 1988), p. 8.

[10]*Ibid.*, p. 18.

[11]Stephanie Epstein, *Buying the American Mind; Japan's Quest for U.S. Ideas in Science, Economic Policy and The Schools*, (Washington, D.C.: The Center for Public Integrity, 1991), pp. 4+.

[12]*Ibid.*, pp. 13-14.

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The views expressed in this report are those of the author and do not necessarily represent those of the Japan Economic Institute.

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